# NOTES ON SILURIAN FOSSILS FROM OHIO AND OTHER CENTRAL STATES.

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[*Concluded from April Number.*]

In the type of *Holocystites abnormis* (Fig. 7) six horizontal rows of plates are indicated distinctly. Several accessory plates are intercalated between the fourth and fifth rows from the top. There is a possibility of a series of very short circum-oral plates. The more or less circular oral aperture apparently had a diameter of five or six millimeters. At a distance of about 4 mm. from the oral aperture, there is an anal protuberance, about 5 mm. in diameter, interrupting the uppermost row of plates. The anal aperture lies along the left margin, but on the rear surface of the specimen as figured by Hall. The granules of this figure represent the internal casts of the numerous vertical pores on the interior of the plates. The surface probably was ornamented by low and rather numerous pustules.

In the second specimen figured by Hall under *Holocystites abnormis* (Fig. 8) accessory plates are present between the fifth and sixth, and between the sixth and seventh rows from the top. The protuberance along the upper left-hand margin of the figure is due, at least in part, to imperfection of preservation.

In the type of *Holocystites alternatus* (Loc. cit. Pl. 12, Fig. 9; Pl. 12a, Fig. 6; see also Pl. 4, Fig. 4, in the present paper) there appears to have been a more or less circular aperture about six mm. in diameter. About 6 mm. from this aperature is the anal protuberance, about 5.5 mm. in diameter. From this protuberance the gut appears to have extended downward, vertically, close to the inner wall of the theca for at least 5 mm. The cast outlining the gut is most distinctly defined on the right side. It appears possible to distinguish certain of the horizontal rows of plates as primary, and others as secondary. The primary plates are larger and appear to number eight in each horizontal row. The secondary plates are smaller and number about 16 in each row; these secondary plates alternately truncate the primary plates or occupy the angles between the latter. In addition to the primary and secondary plates there is a series of accessory plates, of which a pair, instead of a single plate, truncates the primary plates. With this interpretation in mind, the anal protuberance may be said to be located between the first and second rows of primary plates. These are followed, in descending order, by the first row of secondary plates, the third row of primary plates, another row of secondary plates, a

fourth row of primary plates, a partial row of accessory plates, a third row of secondary plates, another partial row of accessory plates, a fifth row of primary plates, and a broken end beyond which there may have been additional rows of primary plates. The surface of the plates probably was marked by low pustules. The interior of the plates evidently was traversed by numerous coarse pores, more or less perpendicular to the surface.

With this group of *Holocystites*, from the Racine limestone of the Silurian of Wisconsin, *Holocystites greenvillensis* is correlated chiefly on account of the presence of horizontal rows of plates, successive rows alternating, and consisting of eight plates each. The anal protuberance is located between the first and second rows of the distinctly outlined plates. The general outline is similar, and there appears to have been a similar absence of arms.

The specimens of *Holocystites greenvillensis* here figured were found in the Cedarville dolomite, about four and a half miles east of Greenville, Ohio, at Brierly's quarry, on Greenville Creek. No exposures exist here at present, the site having long been covered by soil washed in by rains, and rising waters. The elevation here is 980 feet above sea level. At the Lewisburg Limestone Quarry, a mile northwest of Euphemia, the base of the Cedarville limestone is about 975 feet above sea level. For 19 miles south of Euphemia the Brassfield limestone dips between 4 and 5 feet toward the north. Euphemia being about 17 miles south of the Brierly quarry, east of Greenville, this suggests a dip of fully 70 feet northward within that interval, provided the amount of dip does not change. Hence, at the Brierly quarry, the base of the Cedarville dolomite should be about 905 feet above sea level, and the strata formerly exposed in the Brierly quarry should be about 75 feet above the base of the Cedarville limestone, and therefore above the level of the highest strata exposed at Cedarville, Ohio. The Brierly quarry in former days furnished a large number of crinoids and cystids, some of which were listed by A. C. Lindemuth in his Report on the Geology of Darke County, in Volume III, of the Ohio Geology, (p. 515) in 1878. Here the species described in this paper as *Holocystites greenvillensis* was identified as *Holocystites abnormis*.

Most of the species described by S. A. Miller from the Osgood formation of Indiana as *Holocystites* evidently belong to

Jaekel's genus, *Trematocystis*. The remainder belong to closely allied genera. None belong to true *Holocystites*.

There is no evidence that *Holocystites ovatus*, *H. scutellatus*, *H. winchelli*, *H. sphæricus*, or *H. jolietensis*, from the Racine of Wisconsin and Illinois, are closely related to the Osgood forms of *Trematocystis*. Although apparently not congeneric with *Holocystites* as here defined, they nevertheless may prove closely related.

**Hallicystis imago,** Hall. Plate XI, Fig. 2.

The type of *Apiocystites imago*, Hall, numbered 2025, is preserved in the American Museum of Natural History, in New York City. It is figured in the Twentieth Report of the New York State Cabinet of Natural History, on plates 12 and 12a, and the arrangement and outline of the plates has been diagrammed by Schuchert in his paper *On Siluric and Devonic Cystidea and Comarocrinus*, published in the Smithsonian Miscellaneous Collections in 1904. No occasion for further comment on the type specimen would remain were it not for the fact that it presents certain features not noted in any of the preceding studies.

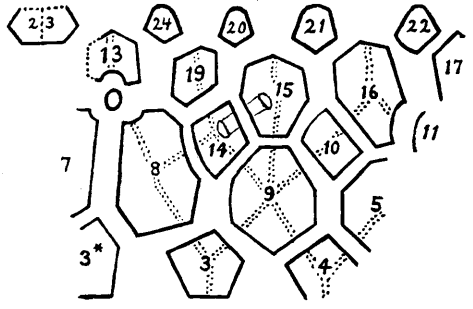


FIG. 1. Plate diagram of type of Hallicystis imago, Hall. The dotted lines crossing the plates indicate the direction of the faint angulations. The double character of plate 23 can not be determined from this type.

In studies of the *Callocystidæ* it is evident that plate 3 supports plates 7, 8, and 9, and thus takes the place of two plates, one alternating with the bases of plates 7 and 8, and the other alternating with the bases of plates 8 and 9. This is true also of the specimen of *Hallicystis imago* diagrammed by Schuchert in the publication cited above.

In the *type* of *Apiocystis imago*, however, plate 3 is represented by two plates. The one alternating with the bases of plates 8 and 9 is completely preserved, and the other, alternating with the bases of plates 7 and 8, is preserved for at least two-thirds of its width. Plates 9 and 5 are in contact with the bases of plates 15 and 16 respectively, being truncated by the latter. Plates 8 and 19 also truncate each other. Plate 24, on the contrary, does not appear to truncate plate 13, and the division of plate 23 into two distinct plates could not be verified in this type specimen, even the outlines of this plate being obscure. The pectinirhombs on plates 14 and 15 apparently were small and discrete, the intervening distance being about 5 millimeters. The cast of the anal orifice is protuberant, and the gut passed from this orifice downward and a little toward the right for a distance of at least 5 mm., the right margin of the cast of the passage along the interior of the theca being more sharply defined on the right side.

Apparently there are obscurely defined remnants of the ambulacral ray No. 5, which terminates at the top of plate 19. There are also weakly defined depressions between plates 20 and 21, and between plates 21 and 22, terminating at the tops of plates 15 and 16 respectively, which suggest the former presence here of rays No. 4 and 3. If these observations are correct, they would confirm Schuchert's reference of *Hallicystis* to the *Apiocystinæ*.

The exterior of the thecal plates apparently was moderately angulated; the direction of the angulations is indicated on the diagram by means of dotted lines. On the basal plates, the median angulation is rather prominent at its lower end.

*Hallicystis imago* occurs in the Racine dolomite, in the Niagaran division of the Silurian, at Racine, Wisconsin.

### **Callocystites jewetti-elongata,** var. nov.
Plate XI, Figs. 6A, 6B, 3.

The internal cast of the theca, (Figs 6 A, B), presenting distinct outlines of all of the plates excepting those on the anal side, is at hand. Even on the anal side sufficient traces remain to warrant the diagram here presented, which evidently is that of a typical *Callocystites*. The line of separation between plates 13 and 24 is unknown, and the double character of plate 23 can not be determined. That half of the pectinirhomb which is on plate 15 is triangularly lunate, and its nearest part is one millimeter from the intermediate suture line; the other half is nearer, but its outline is indistinct. That half of the pectinirhomb which is on plate 5 is slightly incurved on the proximal side, and its nearest part is slightly over 3 mm. from the intermediate suture line; the other half is 3 mm. from the suture line, but its outline is distinctly preserved.

Found in the Cedarville colomite at Cedarville, Ohio.

Compared with typical *Callocystites jewetti*, from the Rochester shale of New York and Ontario, the theca is slightly longer and narrower, being less inflated at mid-length. Moreover, the halves of the pectinirhomb on plates 1 and 5 are much more widely separated from each other. It also is probable that if perfect specimens were at hand that other differences might be noted but the Cedarville specimen evidently is closely related to the Rochester shale species.

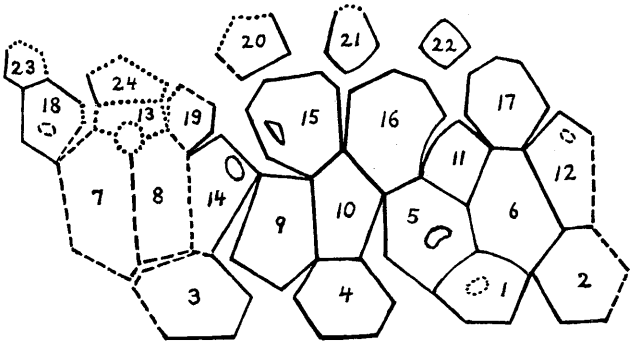


FIG. 2. Plate diagram of Callocystites jewetti-elongata. Poorly preserved outlines indicated by broken lines. The suture lines between plates 13, 19 and 24 are unknown.

At the eastern Mills quarry, southeast of Springfield, Ohio, another fragment of *Callocystites* (Fig. 3) was found in the Cedarville dolomite which evidently also is closely related to *Callocystites jewetti*. The specimen is a fragment of a cast of the exterior of the theca and shows the characteristic deeply and coarsely pitted surface; the sharply elevated margin and elliptical outline of that half of the pectinirhomb which is located on plate 14, and the less strongly elevated margin and more triangular outline of that half which is on plate 15. Plates 9 and 10 are pentangular, 9 with the angle directed downward, 10 with the angle directed upward. The smooth depressed linear area left by the falling off of the ambulacrum is unbranched, and its median part passes somewhat diagonally toward the left of the suture line between plates 9 and 10. Parts of plates 4, 16, 19, 20, and 21, also are present. There is a possibility of this cast of the exterior of the theca being identical specifically with the cast of the interior from the Cedarville dolomite, at Yellow Springs, described in the preceding lines.

**Callocystites sphaeroidalis,** sp. nov. Plate XII, Fig. 5.

Theca globular; only the cast of the exterior of a single specimen is known, but this includes almost half of the specimen. That half of the pectinirhomb which belongs to plate 15 is present and assists in orienting the specimen. Plate 15 truncates plate 9, and plate 16 truncates plate 5; moreover, there is evidence of the complete series of deltoids, 20 to 24, forming the fourth row in *Callocystites*. A crack extends along the left margin of plate 22, along the right margin of the ambulacrum on plate 16, across the left corner of plate 11, and then across plate 5 in a direction parallel to its left margin, where in contact with plate 10. A slight displacement has taken place along this crack, the left part of the specimen being slightly depressed and pushed under the right part. The ambulacrum crossing plate 16 divides dichotomously near the center of this plate, one branch (d) following the line of contact between plates 10 and 5, while the other branch (c) crosses the middle of the latter plate. In addition to this there appears to be evidence of a third branch (x) of the same ambulacrum, passing along the right hand margin of plate 5, intruding slightly on plates 11 and 6. The bifurcation for the third branch takes place near the left angle of plate 11. This second bifurcation of the ambulacrum, although not observed heretofore in *Callocystites*, is to be expected in view of the repeated bifurcations in the later forms included under *Sphaerocystites*. That half of the pectinirhomb which is present on plate 15 possesses about 15 dichopores; it is semilunate in form, there is no evidence of a prominent border, and it is not in contact with the margin of the plate. The surface of the thecal plates is ornamented by small granules, about 4 in a length of 2 millimeters.

Found in the Cedarville dolomite, in the eastern Mills quarry, southwest of Springfield, Ohio.

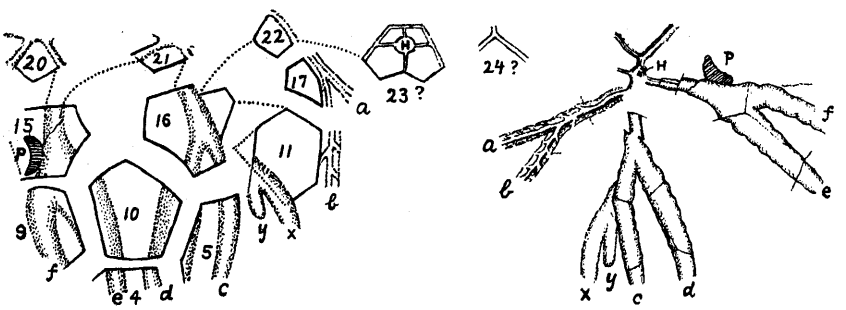


Figure 3. Callocystites sphaeroidalis. Plate diagram on left side, and diagram of ambulacra on right, both only partially preserved; the latter was drawn from a cast of the exterior and, therefore, is inverted from right to left. H, hydropore; p, pectinirhomb; a, b, branches of left posterior ray; c, d, branches of left anterior ray; x, y, apparently supplementary branches; e, f, branches of the anterior ray; the left anterior and anterior rays are indicated only by the grooves left by the fallen-off ambulacrals.

The specimen here described differs from both *Callocystites jewetti*, Hall and *Callocystites canadensis*, Billings, from the Rochester shale, in its globular rather than olive-shaped form, and in its granulose rather than deeply pitted surface.

No comparison with the type of *Hemicosmites subglobosus*, Hall (Twentieth Report, New York State Mus. Nat. Hist., pl. 12, fig. 13, 1868) is possible, for me, since, after repeated attempts, I am unable to orient this type so as to identify the plates. It is evident that the description of the species published by Hall was not based on this type, but upon material similar to that used by Schuchert in his description of *Coelocystis subglobosus*.

The specimen diagrammed by Schuchert as a typical specimen of *Coelocystis subglobosus* agrees so closely with the plate diagram of *Callocystites jewetti* that I am unable to determine upon what features the generic distinction is to rest, unless it be the small size and considerable distance between the discreet halves of the pectinirhombs and the slightly different position and form of plate 24 and of the immediately adjacent deltoids. Since only the internal casts of *Hemicosmites subglobosus*, Hall, and *Cœlocystis subglobosus*, Schuchert, are known, further comparisons are impossible at present.

**Lampterocrinus inflatus-minor,** var. nov. Plate X, Figs. 2A, B.

1868. Lampterocrinus inflatus, Hall, 20th Rep. New York State Cab. Nat. Hist., p. 328, pl. 10, fig. 6.
1900. Lampterocrinus inflatus, Weller, Bull. Chicago Acad. Sci., Nat. Hist. Surv., 4, pt. 1, p. 81, figs. 2, 3.

General shape of the calyx as in *Lampterocrinus inflatus*, apparently with similar pendant, laterally compressed, tubular arms. Ventral disk greatly inflated posteriorly, but the center of radiation of the ambulacra appears to be more nearly central. Height of calyx 22 millimeters, of which the tegmen forms a little more than a third.

Infrabasals, basals, and radials and first costals as in *Lampterocrinus inflatus*. The median part of the second costals curves strongly outward and forms part of the lower side of the pendant arms. The second costals evidently are followed directly by the distichals. Interbrachials apparently as in *Lampterocrinus inflatus*. First anal plate larger than the first plate in the interbrachial areas, higher than wide, followed by three plates of which the middle one is conspicuously longer. The upper half of this middle plate is surrounded by a semicircular series of five plates, of which the end plates reach about the same level as the top of that middle plate which the five plates in question surround.

Found in the Euphemia dolomite, in the Jackson quarry, about two miles south of Covington, Ohio. Differing from *Lampterocrinus inflatus*, from the Racine dolomite of Wisconsin and Illinois, in its much smaller size and in the less conspicuous elevation of the inflated part of the tegmen on the left side of the posterior interambulacral area.

**Habrocrinus benedicti,** Miller. Plate X, Figs. 5A, B.

1894. Saccocrinus benedicti, Miller, 18th Ann. Rep. Dep. Geol. Nat. Res. Indiana, p. 283, pl. 5, figs. 1, 2.
1908. Habrocrinus benedicti, Slocom, Field Columbian Mus., 2, Geol. Ser., p. 295, pl. 87, figs. 6, 7.
1902. Periechocrinus chicagoensis, Weller, Bull. Chicago Acad. Sci., Nat. Hist. Surv., 4, p. 131, pl. 13, figs. 7, 8.

Basals, three; radials, five, forming a single transverse row along with the first plate of the anal interradial area. Each radial followed by two costals; the first, hexagonal; the second, pentagonal, leaving room for distichals, but not for palmers before reaching the base of the free arms. At these arm bases the upper part of the dorsal cup projects strongly as in *Habrocrinus benedicti.* Traces of ornamentation, similar to that characteristic of the latter species, remain. The general appearance of the specimen, including that of the base, is similar to *Habrocrinus chicagoensis*, as figured by Weller.

Found in the lower part of the quarry west of the river at the Wire Works, in the eastern part of Muncie, Indiana, where it is associated with *Halysites labyrinthicus*, *Petalocrinus* sp., *Leptæna rhomboidalis*, *Pentamerus oblongus*, *Gypidula rœmeri*, *Uncinulus stricklandi*, *Platyceras niagarense*, *Phanerotrema occidens*, and *Calymene celebra.* It underlies a horizon, consisting of about a foot and a half of clay shale and very thin bedded limestone, in which there is a recurrence of the Waldron fauna, including the following species: *Duncanella borealis*, *Favosites forbesi-occidentalis*, *Favosites spinigerus*, *Hallopora elegantula*, *Diamesopora osculum*, *Trematopora singularis*, *Eucalyptocrinus* sp., *Atrypa reticulari-newsomensis*, *Anastrophia internascens*, *Camarotœchia acinus*, *Leptæna rhomboidalis*, *Rhipidomella hybrida*, *Rhynchotreta cuneata-americana*, *Schuchertella subplana*, *Spirifer crispus-simplex*, *Whitfieldella nitida*, *Cypricardinia arata*, *Diaphorostoma niagarense*, and *Dalmanites verrucosus.* The clay shale containing this recurrence of the Waldron fauna occurs 45 feet below the level of the railroad track following the western side of the river, at the quarry. Its elevation is approximately 900 feet above sea level.

According to the well record presented by E. P. Cubberley, on page 241 of the Eighteenth Annual Report of the Geological Survey of Indiana, cited above, the thickness of Silurian rock underlying Muncie, Indiana, is 265 feet. This would place the clay shale in the Muncie quarry, containing the recurrence of the Waldron fauna, about 220 feet above the base of the Silurian. Considering the fact that at St. Paul, in the northwestern part of Decatur County, Indiana, the thickness of the Laurel limestone, which directly underlies the true Waldron shale, is 50 feet; that of the underlying Osgood formation, about 8 feet, and that of the Brassfield limestone, if present at all, certainly not more than 20 or 30 feet as the extreme, it is impossible to regard the clay shale layer in the Muncie quarry as identical with the Waldron shale of the more southern parts of Indiana, although evidently containing a recurrence of the Waldron fauna. In fact, it is possible that the fauna exposed in the quarry at Muncie belongs stratigraphically above any Niagaran strata included in the Louisville limestone in southern Indiana, and also above any Niagaran strata referred to the Cedarville dolomite in western Ohio.

Several facts suggest that the clay shale horizon in the Muncie quarry is of later age than the typical Waldron shale. The entire thickness of rock exposed beneath it is massive, without well marked bedding planes, and is strongly dolomitic. Moreover, *Phanerotrema occidens* so far has not been found below the level of the Louisville limestone and Cedarville dolomite.

The rock immediately above the clay shale horizon in the Muncie quarry, for a thickness of 25 feet, is very porous and massive, strongly resembling the Cedarville dolomite of Ohio lithologically. It contains a *Fistulipora* resembling *Fistulipora neglecta-maculata* in general appearance, also a species of *Conchidium*, *Dalmanites verrucosus*, and the unnamed species of *Bumastus* from northern Indiana described by Kindle under *Illœnus insignis*.

Above the massive, very porous rock, in the Muncie quarry, there is a series of thin bedded limestone, the individual layers of which are 3 to 4 inches thick, the total of the layers exposed equalling 12 feet. This is the richly fossiliferous part of the exposures at Muncie. It is best exposed, for purposes of collecting, directly east of the quarry, on the opposite side of the

river. Here it contains: *Cladopora* sp., *Halysites labyrinthicus*, *Favosites niagarensis*, *Favosites spinigerus*, *Spirorbis* sp., *Anastrophia internascens*, *Atrypa reticularis-niagarensis*, a strongly convex form of *Dalmanella elegantula*, *Leptæna rhomboidalis*, *Pentamerus compressa*, *Platystrophia biforata*, *Spirifer* cf. *radiatus*, *Uncinulus stricklandi*, *Calymene celebra*, and the *Bumastus* of northern Indiana described by Kindle under *Illænus insignis*.

*Pentamerus compressus*, Kindle and Berger, is a very different species from *Pentamerus cylindricus*, Hall, and belongs to a much higher horizon. *Pentamerus cylindricus* occurs about 50 feet above the base of the Louisville limestone in the area northeast of Louisville, along the Ohio River. It is unknown in northern Indiana, where the form identified as *Pentamerus oblongus cylindricus* is only a variation of *Pentamerus compressus*. *Pentamerus compressus* was described from the Noblesville dolomite at Delphi, Indiana, and it is to this horizon that the upper part of the exposures at Muncie are referred.

**Habrocrinus** sp. Plate X, Fig. 6.

Basals three; in the cast they diverge strongly producing a lateral outline of about 110 degrees for the base of the calyx. The five radials and the first plate of the anal series are closely similar in size and shape, differing only in the fact that those plates which are directly above the basals are hexagonal in outline, while the intermediate plates are heptagonal. Costals, two, slightly smaller than the radials; the first, hexagonal; the second, heptagonal, supporting a pair of distichals, followed by a second pair. The latter are separated by at least one inter-distichal plate. Apparently no palmers enter into the formation of the dorsal cup; for this reason the specimen here described is referred to *Habrocrinus*.

The first plate of the anal interradial area is followed by three plates, of which the middle one is hexagonal, and the two lateral ones are pentagonal in outline, in each case with a horizontal suture-line at the top. These are followed by a second set of three plates, of which the two lateral plates are hexagonal, and the middle plate is irregularly octagonal in outline. The two sets of three plates just described are subequal in size, and are only moderately smaller than the adjacent costals. The two lateral plates of the second set are each followed by a plate irregularly hexagonal in form, which is only moderately smaller than the plate upon which it rests. The middle, irregularly octagonal plate of the second set, however, is followed by three much smaller plates of which the middle one is hexagonal, and the two lateral ones are pentagonal in shape, one of the angles of the latter being directed upward. These three smaller plates are followed by a transverse series of five plates, also of distinctly smaller size, and the latter by other plates whose arrangement can not be determined from the specimen at hand.

From the Cedarville dolomite, at the eastern Mills quarry, one mile southwest of Springfield, Ohio.

The tegmen of the specimen from Springfield, Ohio, here described, is not preserved. This prevents the elucidation of the following anomalous structure. Apparently an anal tube extends from the upper margin of the right posterior interbrachial area diagonally upward and toward the left. Possibly the right side of the tegmen was crushed in and a part of the anal tube preserved in such a position as to give the present misleading appearance.

The specimen here described differs from *Habrocrinus ornatus*, Hall and Whitfield, from the Cedarville dolomite at Yellow Springs, Ohio, in several important particulars. The form of the dorsal cup is more obovate-globose, and the arrangement of the plates in the anal interradial area is different.

In *Habrocrinus ornatus*, Hall and Whitfield, the first anal plate supports a transverse set of three plates whose upper margins are sufficiently near the same level to cause the next set, consisting of five instead of three plates, also to form a transverse row. The latter is followed by another transverse row consisting also of five subequal plates, and the latter are followed by five plates of smaller size, beyond which extend the basal plates of the anal tube.

In *Habrocrinus benedicti*, Miller, from the Laurel limestone at St. Paul, Indiana, the first anal plate supports a transverse set of three plates, followed by a transverse set of five plates of which the middle and two end plates occupy a distinctly higher position, and the latter are followed by two additional zigzagging sets of five plates. At the bases of the free arms the upper margin of the dorsal cup projects outward. The same general form and arrangement of plates is found in *Habrocrinus chicagoensis*, Weller, from the Racine of Bridgeport and Joliet, Illinois.

In *Habrocrinus howardi*, Miller, the first plate of the anal interradial area is followed by two sets of transverse plates of plates each, and these by a transverse set of five plates which are not in line; but the middle three plates of the last set are not conspicuously smaller than the end plates, the base of the calyx is truncated, and the upper part of the dorsal cup projects strongly at the bases of the free arms.

In *Habrocrinus farringtoni*, Slocom, from the Racine near Lemont, Illinois, the arrangement of the plates of the anal interradial area agrees with that of *Habrocrinus benedicti*.

In *Habrocrinus lemontensis*, Slocom, from the Racine near Lemont, Illinois, the small size and quadrangular form of the first costals is sufficient to distinguish this species from any other described form of *Habrocrinus*.

**Periechocrinus tennesseensis,** Hall and Whitfield. Plate X, Fig. 3.

Saccocrinus tennesseensis, Hall and Whitfield, Geol. Surv. Ohio, Pal. 2, 1875, p. 125, pl. 6, fig. 10.

This species was described and figured from a specimen collected by Prof. Edward Orton in the Cedarville limestone at Cedarville, Ohio, but it is evident that he regarded a specimen in the Troost collection, from the Brownsport division of the Niagaran in western Tennessee, as the type. (Wood, Bull. U. S. Nat. Mus., 64, 1909, p. 76, pl. 6, fig. 10).

In the Ohio specimen figured by Hall and Whitfield, the sides of the calyx diverge at an angle of about 20 degrees, the basal plates diverging apparently at an angle of 105 degrees. At the summit, the calyx is quite abruptly truncated, the tegmen being comparatively flat.

In another specimen, here figured, from the same horizon and locality at Cedarville, Ohio, the lower radials and interradials are slightly broader; and the lateral diameter of the calyx is slightly greater; otherwise it agrees closely with the type.

**Periechocrinus cylindricus,** sp. nov. Plate X, Figs. 1A, B.

Calyx, above the basals, sub-cylindrical, the sides diverging at angles of about 10 degrees, or less. The convex basals diverge so as to form an angle of about 90 degrees with the basal part of the calyx. The top of the calyx is abruptly truncated, the tegmen being comparatively flat, as in *Periechocrinus tennesseensis*, to which the species may be regarded as closely related. Four arms for each ray.

Area of attachment for the column very small, not exceeding 2 millimeters in diameter. Three basals, convex. Radials and first plate of the anal series considerably elongated, the length in extreme cases equalling twice the width. The suture line between the radials and the first one in each of the series of costals is very narrow, the latter also being conspicuously elongated and tapering to a narrow width at the base. As in other species of *Periechocrinus*, there are two costals, two pairs of distichals, and four pairs of palmers in each ray. The first interbrachial plate is large, the first and second pairs of inter-

brachials become rapidly smaller, and the third and following pairs are conspicuously smaller than the rest. Length of largest specimen here figured, 66 millimeters; lateral diameter at top of calyx, 30 millimeters; antero-posterior diameter, 23 millimeters; specimen probably compressed in a direction from front to rear.

Cedarville dolomite, at the eastern Mills quarry, a mile southwest of Springfield, Ohio.

**Dalmanella springfieldensis,** sp. nov. Plate XI, Figs. 5A–E.

Pedicel valve strongly convex, the convexity equalling from five-tenths to six-tenths of the width in the more convex specimens. The beak is strongly incurved. Some of the specimens tend to be angulate along the median line, but this is not a constant feature. Specimens rarely exceed 12 millimeters in length. Casts of the interior indicate the presence of strong dental lamellae, which extend forward from the hinge-line for a distance of two to two and a half millimeters.

Brachial valve only moderately convex or comparatively flat and with the greater convexity about one-third of the length of the valve from the beak; depressed along the median line. Length varying from slightly less to slightly more than the width. Casts of the interior indicate the presence of a small and narrow cardinal process, of strong crural processes, and, in mature specimens, of strongly defined muscular impressions. The median elevation separating the muscular impressions is strongly defined, especially posteriorly where it separates the posterior adductor impressions. The anterior adductor impressions are not strongly differentiated from the posterior impressions, nor are they strongly limited anteriorly, but laterally both sets of impressions are clearly defined.

Surface marked by narrow radiating striae, about 5 to 6, sometimes 7 occurring in a width of 2 millimeters.

From the Cedarville dolomite, at the eastern Mills quarry, southwest of Springfield, Ohio.

This species is characterized by its small size, the great convexity of its pedicel valve, and the tendency toward elongation of the latter. The second specimen figured by Nettelroth (Kentucky Fossil Shells, 1889, Pl. 32, Figs. 55, 56, 57) from the Louisville limestone of Kentucky, evidently is closely similar, and the first figured specimen (Ibid., Figs. 52, 53, 54) illustrates one of the less elongated specimens of the same species.

*Dalmanella elegantula,* Dalman, (Kongl. Svenska Vet.-Akad. Handl., 1828, p. 117, Pl. 2, Figs. 6 a-g) is a much more triangular shell. For the Waldron shale species, so well figured by Hall (28th Rep. New York State Mus. Nat. Hist., 1879, P. 150, Pl. 21, Figs. 11–17) the term *Dalmanella waldronensis* is here proposed.

**Stropheodonta** (?) sp. Plate IX, Fig. 4.

Valve convex anteriorly, the present flattening of the shell posteriorly assumed to have been due, in part at least, to pressure; assumed to be a cast of the exterior of the pedicel valve. The original convexity may have equalled 3 millimeters. Radiately striated with coarse and fine striae. The coarser striae tend to be from three-quarters of a millimeter to nearly a millimeter apart, additional striae being intercalated at about one-third of the length of the shell, and also at two-thirds the length of the shell from the beak. Between these coarser striae there are much finer striae, about four or five occurring between each pair of coarser striae. Shell wrinkled concentrically in a peculiar zigzag manner, excepting along the hinge-line where the wrinkles are obliquely inclined in such a manner as to suggest an acute prolongation of shell at the postero-lateral angle. The zigzag wrinkling suggests the crossing of two sets of wrinkles at angles varying from 70 to 90 degrees on different parts of the valve. Since the specimen consists of a natural cast of the exterior of the valve, no evidence regarding its interior is offered.

Found nine feet above the base of the Cedarville dolomite, at the Lewisburg Stone Company quarry, located a mile northwest of Euphemia, a village directly north of Lewisburg, Ohio. This is the type locality for the Euphemia dolomite. Here the following section is exposed, in descending order:

Cedarville dolomite, lower part very porous.....14 ft. 6 in.
Springfield dolomite, dense, bedded.....7 ft. 9 in.
Euphemia dolomite, rock very porous, and mottled or with whitish blotches.....4 ft 6 in.
Laurel limestone, whitish, resembling Dayton limestone.....8 ft. 10 in.
Osgood clay, middle part shaly, upper and lower part more indurated.....4 ft.
Dayton limestone, light blue, dense.....8 ft.
Brassfield limestone, estimated from drill-hole at.....22 ft.

Strophomenoid shells ornamented with zig-zag wrinkles, or with two systems of wrinkles crossing at various angles, have been known for many years. This type of ornamentation however, probably is not limited to a single genus.

In 1848, Barrande described from the Silurian strata of Bohemia, under the name *Leptæna stephani* (Brachiopoden der Silurischen Schichten von Böhmen, Vol. 2, Pl. 20, Figs. 7 a-h) a form which appears to be a *Stropheodonta* with an ornamentation similar to that of the Devonian species *Stropheodonta patersoni*, Hall, but with a greatly elongated hinge-line and with a remarkably strong curvature antero-posteriorly.

That *Leptæna loveni*, Verneuil (1848, Leptæna a crochet perfore, Bull. Soc. Geol. France, p. 31 of reprint, Pl. 4, Fig. 5), from the Silurian of Gotland, is not a true *Strophomena* is shown by the general concavity of the brachial valve and convexity of the pedicel valve. The species probably is more strophеodontoid than strophomenoid although it presents some anomalous characteristics, and probably should be relegated to a distinct genus. Its surface ornamentation is somewhat similar to that of *Leptæna stephani*, Barrande, but the transverse markings are described as zig-zag in direction.

*Orthis loveni*, Lindstrom (Gotlands Brachiopoder, Oversigt af K. Vet. Akad. Forhandl., 17, 1861, P. 369, Pl. 13, Fig. 12), from the Silurian of Gotland, is a species of *Rhipidomella* closely resembling *Rhipidomella hybrida* and does not present the transverse zig-zag ornamentation here in question (Hall and Clarke, 1894, Pal. New York, 8, Pt. 2, P. 359).

*Strophomena julia*, Billings (Palæozoic Fossils, Canada, 1865, P. 127, Fig. 105, a, b) from the Jupiter River division of the Silurian on Anticosti Island, also appears to be a strophеodontoid species, judging from the very narrow deltidium and the interior of the brachial valve. The transverse undulations cross each other more or less in zig-zag manner.

Similar forms of shells, probably strophеodontoid in character, were described by Kindle (Mus. Bull. 21, Canada Geol. Surv., 1915, P. 13, 14, Pl. 1), from the Silurian dolomite of the lower Saskatchewan River valley in Manitoba, Canada, under the terms *Leptæna sinuosus* (Figs. 1–4) and *Leptæna parvula* (Figs. 5–9). Transverse wrinkles cross each other more or less in zig-zag manner.

*Orthis* (?) *glypta*, Hall and Clarke (1894, Pal. New York, 8, Pt. 2, P. 359, Pl. 84, Figs. 8, 9), from the Racine dolomite near Milwaukee, Wisconsin, with diagonally intersecting wrinkles, also may be a strophеodontoid, rather than an orthoid shell.

Of the forms here cited, *Leptæna stephani*, Barrande, has little in common with the remaining species. The remainder may be congeneric. Too little is known at present, however, regarding their internal markings to verify this suggestion. Although apparently strophеodontoid in character, they may form a distinct genus, not because they have a similar surface ornamentation, but because these Silurian representatives of the strophеodontoid group may present characteristics not shared with the typical late Devonian species of *Strophеodonta*.

**Stricklandinia** (?) **louisvillensis,** Nettelroth. Plate X, Figs. 7A,B.

1889. Stricklandinia louisvillensis, Nettelroth, Kentucky Fossil Shells, p. 65, pl. 34, figs. 31-34.

Brachial valve from 20 to 23 millimeters in length, with maximum convexity between one-fourth and one-third of the length of the valve from the beak. This convexity equals about 5 millimeters, and there is a tendency toward flattening anteriorly. Low and broad plications mark the valve medially and along the anterior margin, where frequently they are three millimeters in width, varying to two millimeters on the sides of the valve. In one specimen the plications along the median part of the valve are conspicuously narrower than the remainder. Toward the beak and along the postero-lateral parts of the valve the plications become obsolete. The hinge-area apparently was low, and the beak did not curve beyond the plane of junction of the two valves. Two sharp parallel narrow ridges, about one millimeter apart and eight millimeters in length, extend forward from the beak, on the interior of the valve, and are interpreted as crural ridges, terminating posteriorly at what appear to be triangular crural plates.

Three valves, from the Cedarville dolomite at the eastern Mills quarry, southwest of Springfield, Ohio, of which two are figured here, closely resemble the type of *Stricklandinia louisvillensis*, preserved in the U. S. National Musuem.

The two parallel crural ridges of the brachial valves here described do not suggest a spiriferoid shell, nor would they be expected in a species of *Stricklandinia*. They might occur, however, in a pentameroid shell. It is evident that more material is needed for the elucidation of the affinity of these shells. Nothing is known of the interior of typical *Stricklandinia louisvillensis*, as found in the Lousiville limestone at Louisville, Kentucky. Only the exterior of the type is known, and in this the beaks of both valves are closely appressed and no delthyrium is seen. Its generic relationship remain uncertain.

Two pedicel valves, having about the same size and form as *Stricklandinia louisvillensis*, and marked by similar low broad plications, were found in the Cedarville dolomite at Cedarville, Ohio. They differ however, in other particulars. The cardinal area has a height of at least three millimeters; the beak has a correspondingly greater prominence, and probably extended considerably beyond the beak of the brachial valve although only moderately incurved. The sides of the open delthyrium form an angle of about 40 degrees. There is a faint depression along the median part of the shell, its sides forming an angle of about 20 degrees with each other. This depression is almost

flat, or is occupied by a single, almost obsolete, low, broad plication. Two thin dental plates extend forward from the beak for a distance of 6 mm. Where they rest on the interior of the valve, they form an angle of about 30 degrees with each other. Midway between them there is a low but thin and sharp median ridge, as in some species of *Spirifer*, and the general aspect of these pedicel valves is spiriferoid. In this respect they differ from the ventral valve of the type of *Stricklandinia louisvillensis*, so that it is possible that the pedicel valves are even generically distinct from the brachial valves described above, notwithstanding their general resemblance. (Figs. 7 A, B, on plate XII.)

**Dictyonella reticulata,** Hall. Plate X. Figs. 4A, B.

The first published figures of *Dictyonella reticulata*, from the Waldron shale, at Waldron, Indiana, occur in the Twentieth Report on the New York State Cabinet of Natural History, page 275, 1867. Here Figures 1 and 2 indicate the presence, on the brachial valve, of a median fold distinctly defined from the beak to the anterior margin, the sides of the fold forming an angle of 30 degrees. These figures are reproduced in the Eleventh Report on the Geology and Natural History of Indiana, 1881, where they form Figures 53 and 54 on Plate 26. An examination of the series of type specimens, preserved in the American Museum of Natural History, and there numbered 1,944, indicates the presence of four individuals, including all of those figured in the Indiana report. In none of these is the median fold as distinctly defined as indicated in the figures mentioned above; in fact, it is readily distinguished only under cross illumination, and then only anteriorly, the posterior part, toward the beak, being almost obsolete. Moreover, the angle made by the sides of the median fold, if the lateral slopes of the latter be included, is nearer 35 degrees. The specimen first figured by Hall, regarded as the type of the species, is illustrated in the present publication by Figure 7 on Plate XI.

In *Dictyonella corallifera*, Hall, figured on Plate 58, of the second volume of the Paleontology of New York, from the Rochester shale of New York, both the median fold on the brachial valve and the corresponding sinus on the pedicel valve are distinctly defined from the beak to the anterior margin.

The fold is higher and narrower, and therefore, more convex, the angle made by the sides averaging 20 degrees or less. The specimen illustrated by Figure 5c in the Paleontology of New York is represented by Figure 8 on Plate XI of the present publication.

At Harrods Creek, about five miles northeast of Louisville, Kentucky, a specimen of *Dictyonella* was found in the Upper Osgood clay, which here forms a layer about three and a half feet thick, 20 feet below the level of the traction bridge, about 200 yards up stream from the bridge. Here it is associated with *Cyathophyllum calyculum*, *Eucalyptocrinus*, *Hallopora elegantula*, *Orthis flabellites*, *Rhipidomella hybrida*, *Leptæna rhomboidalis*, *Atrypa reticularis*, and *Diaphorostoma niagarensis*. The Upper Osgood clay is underlaid by the Osgood limestone, six feet thick, with one of Miller's species of *"Holocystites"* (*Trematocystis* ?) at the base. This is underlaid by the Lower Osgood clay, consisting, in descending order, of massive, indurated clay rock, 9 feet thick, spalling where exposed to weathering; chiefly purplish clay, 3 feet thick; and more indurated clay rock, 8.5 feet thick. In the underlying Brassfield limestone *Orthis flabellites* is associated with *Rhinopora verrucosa*.

The *Dictyonella* found in the Upper Osgood clay is scarcely distinguishable from the *Dictyonella reticulata* occurring in the Waldron shale. It possesses the same low median fold, not strongly defined laterally, and becoming more or less obsolete toward the beak. The surface markings are closely similar, and, although appearing more circular on some parts of the shell, are equally quadratic on others. (Figs. 4 A, B, on plate X.)

It is interesting to note that this Osgood form of *Dictyonella* finds its nearest relative in the Waldron species, *Dictyonella reticulata*, rather than in the Rochester form, *Dictyonella corallifera*.

**Camarotoechia roadsi,** sp. nov. Plate XII, Figs. 6 A-E.

General outline rotund subtriangular, especially when viewed from the side of the pedicel valve. Pedicel valve only moderately convex in appearance since the antero-lateral parts have almost the same elevation as the umbonal parts of the valve. Brachial valve strongly convex, especially anteriorly, along the median fold, where the median parts are conspicuously elevated above the lateral parts of the valve. Median fold with four plications, the lateral ones narrower and at a somewhat lower elevation. Lateral plications, on each side, five or six, sometimes

seven. Median sinus with three plications. The plications are relatively low and rounded and are separated by shallow grooves; posteriorly they usually are inconspicuous and in some specimens are almost obsolete. The cuneate muscular area of the brachial valve evidently was slightly raised above the general level of the inner surface. This muscular area is traversed by a median septum which divides posteriorly into a narrow spondylium. A similar but broader muscular area, without a median septum, characterizes the pedicel valve. The dental lamellæ of the pedicel valve extend downward so as to rest upon the inner surface.

From the richly fossiliferous limestone layer about nine feet above the base of the West Union formation, in the valley on the southeastern margin of Hillsboro, Ohio. Named in honor of Miss Katie Roads.

*Camarotœchia roadsi* belongs to a group of species characterized by low rounded plications tending to become obscurely defined or even almost obsolete posteriorly. Compared with *Camarotœchia obtusiplicata*, Hall, from the Rochester shale of New York, the outline is more triangular, the plications are lower and more nearly obsolete posteriorly.

*Rhynchonella pisa*, Hall and Whitfield, was described by them as "globular in full-grown specimens" and therefore figures 18 and 19, accompanying the original description, must be regarded as illustrating the type. The angulate course of the plications of the brachial valve in figure 19 explains why "the more ventricose forms resemble very closely small specimens of *Rhynchonella nucleolata*, Hall," a typical species of *Uncinulus* according to the present system of classification. The type of *Rhynchonella pisa* was obtained from the same horizon as *Camarotoechia roadsi*, in the lower or Bisher member of the West Union formation, at Danville, southwest of Hillsboro, Ohio.

**Trochurus phlyctainodes,** Green. Plate XI, Figs. 1A-D. Plate XII, Figs. 1A-D.

1837. Calymene phlyctainodes, Green, Amer. Jour. Sci., 32, p. 167.

Median lobe of glabella most strongly arched from front to rear at a point one-sixth of its length, measured along its surface, from the posterior end; widest one-third of its length from the rear, narrowing to four-fifths of this width anteriorly, and to three-fifths of this width posteriorly. Compound anterior lateral lobes widest slightly anterior to mid-length, equalling in width the immediately adjacent part of the median lobe; strongly defined from the median lobe by deep furrows at least a millimeter in width, equally well defined from the third lateral

lobes by almost equally deep but narrower furrows; viewed from the rear, these lobes lie distinctly below the general surface of the median and third lateral lobes. Third lateral lobes equalling in width the posterior end of the median lobe, pyriform with the narrow end directed toward the median axis of the glabella; distal end about four millimeters from the suture line at the palpebral lobe. Occipital lobes small, triangularly ovate, with the narrower end directed toward the axis of the glabella, the width equalling three-fourths of the length, sharply defined from the third lateral lobes and from the occipital segment by narrow furrows. In width, these occipital lobes equal almost one-half of the width of the third lateral lobes, but they are low and much less conspicuous. Occipital segment subtriangular when viewed from the front, owing to the prolongation of the median parts into a spine. The length of this spine can not be determined from the specimen at hand since only the basal portion remains. Immediately anterior to the occipital segment and posterior to the median lobe the surface of the glabella is strongly depressed. Anteriorly the median and compound anterior lateral lobes are strongly defined from the border of the cephalon by a deep furrow, fully a millimeter and a half in width anterior to the median lobe. The facial suture is about 3 mm. distant from the lateral margins of the compound anterior lateral lobes, as far as the very small palpebral lobe, beyond which it curves almost rectangularly outward, its further course not being shown by the specimen at hand. General surface of the glabella thickly covered with tubercles of various sizes. Some of the larger of these probably supported short spines. Several of these may have been scattered along the middle third of the median lobe and one or two may have been present near the middle of the third lateral lobes. It is certain that the two conspicuous spines near the anterior end of the median lobe, and the single conspicuous spine at the distal end of the third lateral lobes, figured by Weller (Trilobita of Niagaran limestone in Chicago area, Chicago Acad. Sciences, 1907, pl. 22, figs. 1-4) from the species of *Trochurus* occurring in the Chicago area are absent in the Ohio specimen here described.

From the Cedarville dolomite at the eastern Mills quarry, southwest of Springfield, Ohio.

The type of **Trochurus phlyctainodes,** (Plate XII, Figs. 1 A-D), described by Green under *Calymene*, was found within two miles of Springfield, Ohio, in limestone used to construct the National Pike. To anyone acquainted with the Springfield area it is evident that the only limestone within a convenient distance from the National Pike is located west of Springfield, north of Mad River, within a mile of the eastern Mills quarry at Limestone City, and that the so-called limestone was the rock known at present as the Cedarville dolomite. Casts of this type, numbered 54 in the series of casts prepared by Green, are preserved in the U. S. National Museum at Washington, at the American Museum of Natural History in New York City, and elsewhere. In

these casts, the narrow median lobe of the glabella, humped posteriorly and narrowing slightly anteriorly, closely resembles that of the Mills quarry specimen, here figured and described, thus presenting the most characteristic feature displayed by the latter. The compound anterior lateral lobes and the anterior outlines of the third lateral lobse also are similar but it is evident that the posterior part of the third lateral lobes was cut away in cleaning the original specimen, thus producing a straightness of outline which is entirely misleading. Moreover, the transverse furrow between the posterior end of the median lobe and the connecting ridge joining the third lateral lobes, and the furrow between this connecting ridge and the occipital segment, both are unnaturally deep, and narrow, showing distinct tool marks in some of the casts. Evidently the cleaner thought that these furrows should agree in sharpness and depth with the furrows separating the compound anterior lateral lobes from the median and third lateral lobes. In a similar manner, the posterior margin of the occipital segment shows evidence of the cleaners tool, and it is not at all unlikely that in the original of the cast, before cleaning, this segment was subtriangular in outline, as in the Mills quarry specimen here figured. Compared with the latter, the ornamentation on the surface of the cast is much coarser, and there is no evidence of numerous smaller papillæ among the coarser pustules; this, however, could scarcely be regarded as a specific distinction, in the absence of other well-marked differences. There is no trace of occipital lobes, nor of any remnant of the anterior border visible in these casts.

**Trochurus hanoverensis,** Miller and Gurley (Plate XII, Figs. 2 A-D), from the Laurel limestone at Madison, Indiana, was found by rock breakers while repairing the Hanover pike. Compared with *Trochurus phlyctainodes,* the median lobe is much wider, and its curvature from front to rear is more regular, its outline forming almost three-fourths of a circle. There appears to have been a strong spine near the lateral extremity of each of the third lateral lobes. The occipital lobes are low and inconspicuous. The posterior margin of the occipital segment is unknown.

**Trochurus byrneasnus,** Miller and Gurley, (Plate XII, Figs. 3 A-E), occurs in the Laurel limestone at Madison, Indiana, associated with *Trochurus hanoverensis, Sphærexochus romingeri,* and a large *Encrinurus* pygidium. No *Pentamerus oblongus* occurs at this horizon. *Trochurus byrnesanus* is characterized by a narrow median lobe with subparallel sides; its dorsal outline is nearly straight and anteriorly it is strongly curved downward and backward, the outline between this bend and the anterior border of the cephalon being gently convex. Seen from above, the compound anterior lateral lobes have about the same width as the median lobe, and the transverse furrow limiting the posterior margin of these three lobes is almost straight. The lateral extremities of the third lateral lobes are elevated apparently into short spines. Only one side of the occipital segment is preserved and its median termination is unknown.

**Trochurus nasutus,** Weller, from the Racine division of the Niagaran near Milwaukee, Wisconsin, differs chiefly in the anterior prolongation of the median lobe into a spine. The lateral extremities of the third lateral lobes are not elevated nor conspicuously spinose. The occipital lobes are not conspicuous.

**Trochurus welleri,** Nov. sp. (*Corydocephalus phlyctainodes*, Weller, 1907, Bull. Chicago Acad. Sci., Nat. Hist. Surv., 4, pt. 2, p. 234, pl. 22, figs. 1–4), from the Racine division of the Niagaran near Lemont, Illinois, resembles *Trochurus hanoverensis* in the more even curvature of its median lobe from front to rear; however, the anterior marginal part is not curved as far backward, and the curvature is only moderate near the posterior end of this lobe. In addition to the conspicuous spines terminating the lateral ends of the third lateral lobes, there is a conspicuous pair of spines on the median lobe, anteriorly. Named in honor of Prof. Stuart Weller, of Chicago University.

**Trochurus halli,** Nov. sp. Plate XII, Figs. 4A-D; (*Arges phlyctainodes*, Hall, 1852, Pal. New York, 2, p. 314, pl. 70, figs. 2a-2c), from the Rochester shale near Albion, New York, is closely related to *Trochurus byrnesanus*. It differs chiefly in the curvature of the median lobe of the glabella, from front to rear; this curvature is greater anteriorly, but it is not strongly accentuated antero-dorsally, nor accompanied by a straightening of the dorsal outline as in that species. Viewed from the dorsal side, the anterior part of the median lobe is less prominent, the furrows separating the third lateral lobes from the compound anterior lateral ones diverge more to the front laterally, and there is no indication of spines terminating the lateral ends of the third lateral lobes. Named in honor of James Hall, the great founder of American Paleozoic Paleontology.

A line of progression should extend apparently from *Trochurus halli*, in the Rochester shale, through *Trochurus byrnesanus*, in the Laurel limestone, to *Trochurus nasutus*, in the Racine division of the Niagaran.

Trochurus hanoverensis, from the Laurel limestone and *Trochurus welleri*, from the Racine evidently belong to another group. From one of the earlier members of this group, *Trochurus phylctainodes* could have diverged by a more bulbous development of the posterior end of the median lobe and a greater downward extension of the anterior parts of the cephalon.

Prof. Percy E. Raymond has called to my attention that *Corydocephalus* is antedated by *Trochurus* as follows: *Trochurus* was founded by Beyrich in 1845 (Ueber Bohm. Tril. p. 31, pl. 1, fig. 14) on *Trochurus speciosus*, sp. nov. (Beyrich), this species being illustrated by a figure of the pygidium, the name *Trochurus* (wheel) alluding to the general appearance of the pygidium (a wheel with spokes). Unfortunately Beyrich described under *Trochurus speciosus* also the head of a *Staurocephalus*.

His attention being called to his error privately by Barrande, Beyrich figured the proper cephalon for his species in 1846, and definitely designated the pygidium as the type. *Corydocephalus* was not defined by Hawle and Corda until 1847 (Prodr. Mon. Bohm. Tril., p. 139, pl. 7, fig. 4), and was based on the same species, although the specimen he figured was regarded by him as a new species (*C. flabellatus*, sp. nov. Corda). Barrande described the same species in 1846 as *Lichas palmata*, owing to Beyrich's error in his original description of *Trochurus speciosus*.

## Appendix: Two Species of Ordovician Fossils.

### **Lingulops cliftonensis,** Foerste. Plate X, Fig. 9.

1903. Lingulops cliftonensis, Foerste, Jour. Geol. vol. 11, p. 38.

Pedicel valve 6 millimeters long, 3.5 millimeters wide, with an elliptical outline similar to that of *Lingulops norwoodi*, James, from the upper part of the Cynthiana formation, at West Covington, Kentucky. The distinct part of the muscular area is thickened over its entire surface, forming a low platform, with an elevation of about a sixth of a millimeter along its anterior margin. The lateral margins of this platform diverge at an angle of about 25 degrees. The oblique anterior margins converge at an angle of about 85 degrees. The width of the platform at its antero-lateral angles is 1.8 millimeters. The median muscular scar, with parallel margins as in *Lingulops norwoodi*, has a width of slightly less than half a millimeter. That part of the anterior margin of the platform which is in front of the median scar curves acutely forward and unites with the narrow median septum, at least a millimeter in length, which extends forward to within less than a millimeter from the anterior margin of the valve. Anteriorly, the median muscular scar bears a faint median striation. Posteriorly, the lateral muscular scars of the platform are limited at a point 2.5 millimeters from the acute anterior termination of the median scar. Half a millimeter farther back lie the posterior margins of the three crescentic lobes of the faint muscular impression characteristic of the genus *Lingulops*. Of these lobes, the median is equal to or is slightly larger than the two lateral lobes. The faint lateral impressions, on each side of the platform, appear to be similar to those of *Lingulops norwoodi*.

From the preceding description it is evident that *Lingulops cliftonensis* resembles *Lingulops norwoodi* much more closely than was suspected at the time of the original description of the species. The presence of the anterior median septum was not known until recently, when the shell of the type specimen was removed, so as to expose fully the natural cast of the interior of the valve. From the latter species, *Lingulops cliftonensis* differs

chiefly in the more acute anterior termination of the muscular platform. Apparently the lateral walls of this platform are more divergent. It is doubtful whether the elevation of the median and lateral muscular scars upon a platform may be regarded as a distinguishing feature, since the growth of this platform may be merely a gerontic feature.

*Lingulops cliftonensis* occurs in the lower or limestone division of the Fernvale member of the Richmond group as exposed at Clifton, Tennessee. For the strata included in the Fernvale member the present writer proposed the name Leipers Creek bed, the term bed being used in the same significance as the term member (Bull. Geol. Soc. Am. Vol. 12, 1901, pp. 432, 433). Although the term Leipers Creek bed preceded that of Fernvale in time of publication, the latter was so much better defined by Ulrich and Hayes (Columbia Folio, 1903), and has entered so fully into literature that no possible good can come of any attempt to revive the term Leipers Creek bed.

*Lingulops cliftonensis* is of interest chiefly as being another species occurring in Richmond strata, closely allied to species occurring at a lower horizon than the Eden group, but not known either from the Eden or from the Maysville group of strata.

**Schuchertella higginsportensis,** Foerste. Plate IX, Figs. 2A, B.

1912. Strophomena higginsportensis, Foerste, Bull. Sci. Lab. Denison Univ., 17, p. 37, pl. 2, figs. 3 A, B; pl. 10, fig. 4.
1914. Strophomena higginsportensis, Foerste, Jour. Cincinnati Soc. Nat. Hist., 21, p. 130, pl. 1, fig. 9.

The pedicel valves, illustrated in the publications cited above, are similar to those of *Schuchertella subplana*, Conrad, widely distributed in the Niagaran rocks of North America, in the small size and general form of the muscular area. The deltidium is well developed. The exterior of the valve is moderately convex toward the beak, and comparatively straight from the beak to the anterior and lateral margins.

More recently, a single brachial valve, exposing the interior, has been found. This also differs distinctly from *Strophomena*. The cardinal process is short and bilobed. The lobes diverge from each other, and each lobe bears on its upper surface a distinct groove, the two grooves converging toward the beak, as in some species of *Schuchertella*. The margin of the crural plates curves outward laterally, and terminates in a curve rising toward the cardinal margin. The dental sockets are distinct. There is no evidence of a deltidial fold passing across the top of the cardinal process as in *Schuchertella subplana*. There may be a low and broad, but indistinct median elevation anterior to the cardinal process, but it is certain that no other structure is noted.

The brachial valve here described was found in slabs that had dropped from the *Eridorthis* horizon at Ivor, Kentucky. At this locality the Fulton clay, characterized by the presence of *Triarthrus becki*, Green, occurs 70 feet above the level of the railroad track. A single specimen of *Eridorthis* once was found in the layer of limestone immediately beneath the Fulton clay, but the species is much more common in some of the overlying horizons, although, owing to the steepness of the quarry-face, the exact location of this horizon is difficult to determine here.

At the quarry west of Point Pleasant, Ohio, the Fulton clay, containing *Triarthrus becki*, is about 55 feet above the level of the pike. The immediately underlying layer of limestone is strongly ripple marked, and a single specimen of *Eridorthis* was found imbedded in its upper surface. Loose limestone slabs, containing a greater number of specimens of *Eridorthis*, were found at 14, 20, and 27 feet above the base of the Fulton layer. Evidently *Eridorthis* must be abundant somewhere above these horizons.

At the quarry in the northeastern part of New Richmond, Ohio, the Fulton clay, containing *Triarthrus becki*, has a thickness of at least five feet. A specimen of *Eridorthis* was found at the top of the immediately underlying layer of coarse grained limestone. *Eridorthis*, associated with a *Leptæna*, provisionally identified as *Leptæna gibbosa*, James, is comparatively abundant in a thin layer of limestone occurring within one foot above the base of the Fulton clay. *Eridorthis* occurs in situ also in a four inch layer of conglomeratic limestone, located about 29 feet above the base of the Fulton clay. This may have been the horizon which furnished the loose slabs, containing *Eridorthis*, in the quarry west of Point Pleasant, Ohio, and this also may have been the approximate horizon for the specimen of *Schuchertella higginsportensis*, obtained at Ivor, Kentucky.

*Schuchertella* has not been identified hitherto from strata below the Silurian. It may be that when the material now congregated under *Schuchertella* is studied more closely that species here described as *Schuchertella* may be separated from that genus, but at present this reference to *Schuchertella* appears at least more logical than its former reference to *Strophomena*.

The exterior of a brachial valve, figured here (Fig. 2B) as belonging to *Schuchertella higginsportensis*, is characterized by

about 21 stronger radiating striæ, separated by an equal number of finer striæ. Intercalated with these two sets is a third set of still finer striæ, about 40 in number, and finally, toward the margins, there are still finer striæ, visible only under a lens, so that the total number of radiating striæ must equal about 150. These are crossed by numerous, fine, sharp, concentric lines. The median depression, seen in the figure, is regarded as due to pressure, resulting in flattening and moderate distortion.

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## EXPLANATION OF PLATES.

### PLATE VIII.

Fig. 1. Zaphrentis digoniata. A, right side; B, anterior side; C, basal view, with corallum inclined so as to show more of the right side; D, E, two silicified specimens, showing the cardinal fossula, sides of calice weathered away. F, view of cast of interior of calice; G, lateral view, showing cast of cardinal fossula. A-E, from top of West Union formation, in Zink quarry, at Hillsboro, Ohio.

Fig. 2. Calostylis parvula. A, specimen showing pores in central area and through the septa; also showing lateral connections or synapticula between the outer part of the septa; also shown enlarged in figure 5, on plate II. B, C, lateral views of two specimens. D, E, calicular views of two specimens. F, view of E, enlarged 4 diameters, showing pores in the central vesicular mass, and several distinct synapticula on the left side of the figure. From the upper part of the Laruel limestone at the Reinheimer quarry, southwest of New Paris, Ohio.

Fig. 3. Holophragma calceoloides. A, B, right side of two specimens; C, D, anterior views; E, F, G, posterior views. H, anterior view with specimen inclined so as to show interior of a nearly circular calice; I, same specimen, enlarged 4 diameters. J, K, similar views of a specimen with a more flattened cardinal side. In both H and J the anterior margin of the calice is weathered away. From the top of the West Union formation, in the Zink quarry, at Hillsboro, Ohio.

In all figures, a indicates the location of the alar septa; c, of the cardinal septum; f, the cast of the cardinal fossula; x, the slightly more prominent lateral septa in some specimens of Holophragma.

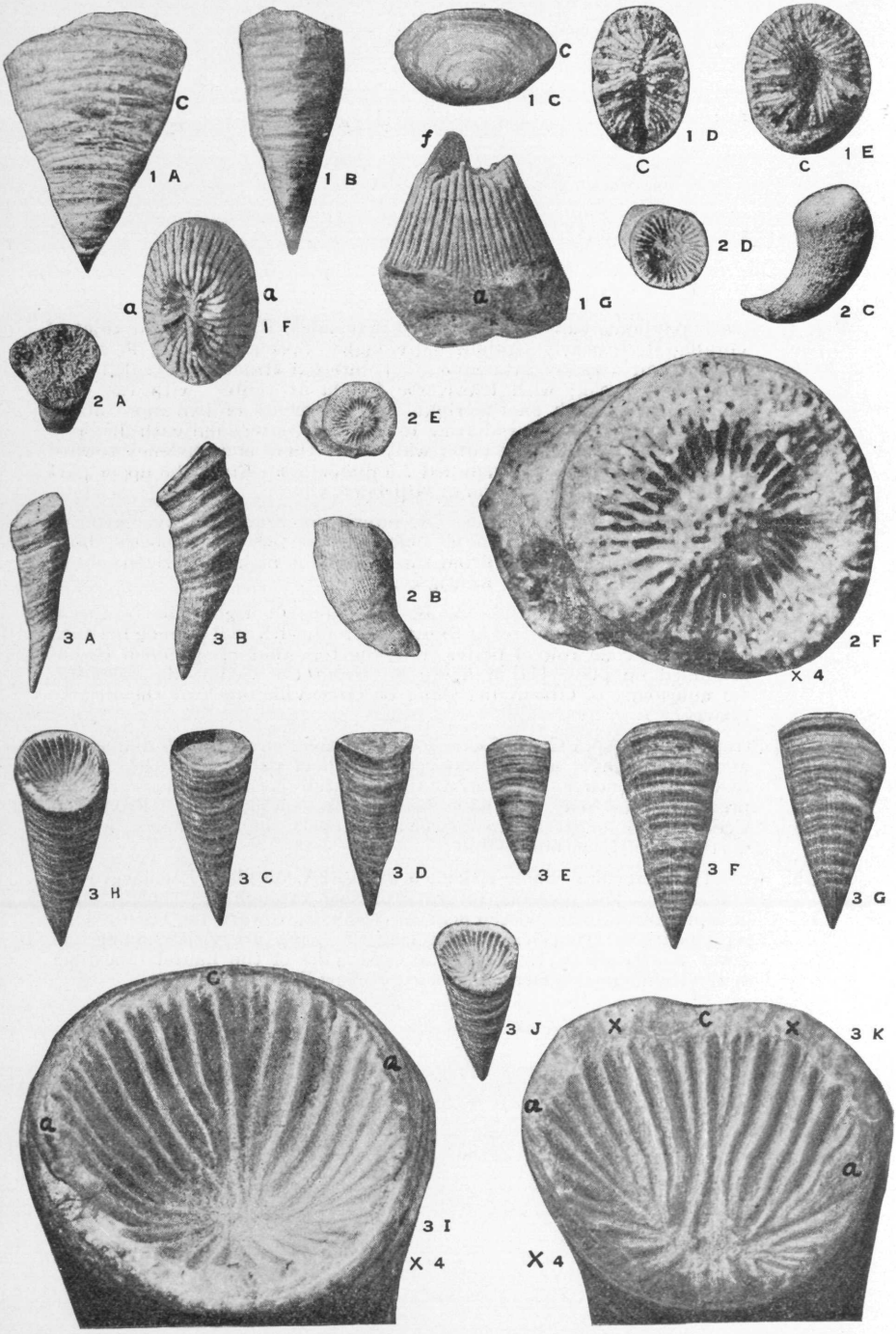


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PLATE IX.

Fig. 1. Cyathophyllum roadsi. A, B, C, D, left sides; E, F, G, right sides of coralla; H, I, nearly straight individuals. Specimens B, E, F, and H retain their areas of attachment. J, internal structure revealed by a transverse break; with transverse tabula at center, with the edge of another beneath on the right, and fragments of two more above on the left; with septa radiating toward the center, and with disseppiments numerous near the outer wall where there is a tendency toward filling by stereoplasm; magnified 2.5 diameters. From the upper part of the West Union formation at Hillsboro, Ohio.

Fig. 2. Schuchertella higginsportensis. A, interior of brachial valve; exterior of another valve regarded as belonging to the same species; both enlarged 2.5 diameters. From the Eridorthis nicklesi horizon, above the Fulton clay, at Ivor, Kentucky.

Fig. 3. Holocystites greenvillensis. A, B, left sides; C, right side of theca; three specimens, imperfect at top and bottom, with anal opening between first and second row of plates from the top, that of specimen B diagrammed on plate III in figure 8. From the Cedarville dolomite, 4.5 miles east of Greenville, Ohio, on Greenville creek at the Brierly quarry.

Fig. 4. Stropheodonta sp. Cast of exterior of a valve, enlarged 2.5 diameters, assumed to have been the convex or pedicel valve since the cast is distinctly concave anteriorly. The postero-lateral angles are not preserved and may not have been acute, as indicated. From the Cedarville dolomite at the Lewisburg Stone Company quarry, a mile northwest of Lewisburg, Ohio.

Fig. 5. Calostylis parvula. Same specimen as fig. 2A, on plate I, enlarged 4.5 diameters. The presence of pores passing through the central mass of septa and tabulae is seen near A, especially toward the right. Disseppiments or synapticula connecting the septa are visible along the lower weathered part. From the upper part of the Laurel limestone at the Reinheimer quarry, southeast of New Paris, Ohio.

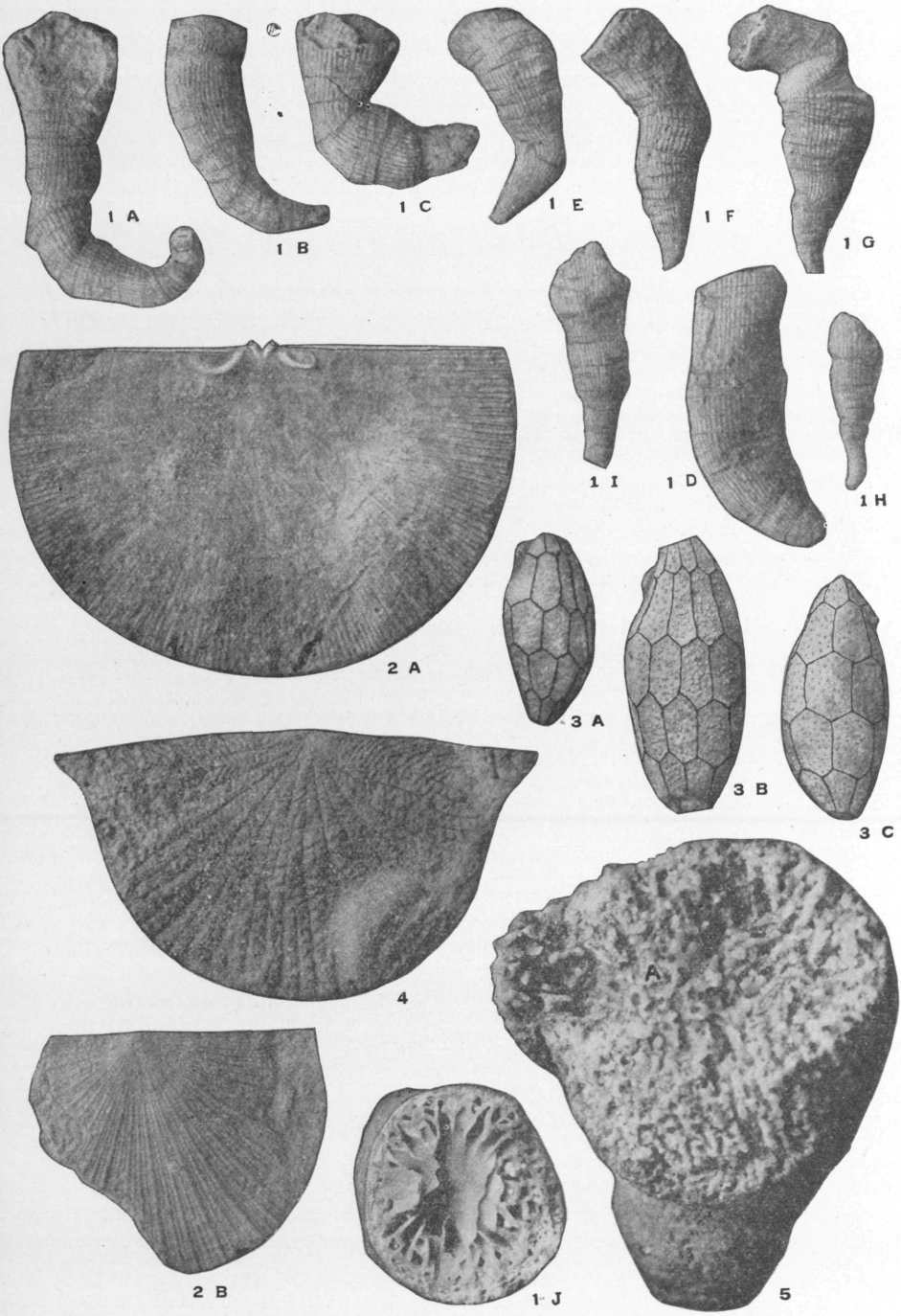


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PLATE X.

Fig. 1. Periechocrinus cylindricus. A, internal cast, retaining outlines of one of the sets of interradial plates on the left, beginning with *ir*. B, another cast, retaining outlines of anterior brachial series, immediately above radial *r*, and also of the adjacent interradial sets of plates. From Cedarville dolomite, at the eastern Mills quarry, southwest of Springfield, Ohio.

Fig. 2. Lampterocrinus inflatus-minor. A, posterior view of internal cast, with tegmen strongly inflated on left side of posterior interradial area; *pb*, posterior basal, with infra-basals beneath. B, view of right anterior interradial area; the inflated posterior part of tegmen not seen on account of tilting; *Ar*, anterior radial. From euphemia dolomite, at Jackson quarry, two miles south of Covington, Ohio.

Fig. 3. Periechocrinus tennesseensis. Interior cast; *Ar*, anterior radial. From the Cedarville dolomite at the eastern Mills quarry, southwest of Springfield, Ohio.

Fig. 4. Dictyonella reticulata. A, brachial valve; B, same, enlarged 2.5 diameters. From upper Osgood clay, at Harrods Creek, 5 miles northeast of Louisville, Kentucky.

Fig. 5. Habrocrinus benedicti. A, anterior view, *Ar*, anterior radial; plates absent from upper part of body. B, view of internal cast of tegmen, with base of anal tube; right posterior ray terminating in two arms. Found in lower part of quarry in eastern part of Muncie, Indiana, on west side of river, above the horizon of the Cedarville dolomite of Ohio.

Fig. 6. Habrocrinus sp. Posterior view, with upper right-hand part crushed in, accompanied apparently by a displacement of the anal tube whose present location is indicated by the dotted lines; *X*, first anal plate. From the Cedarville dolomite at the eastern Mills quarry, southwest of Springfield, Ohio.

Fig. 7. Stricklandinia louisvillensis. Two brachial valves.

Fig. 8. Holocystites greenvillensis. Diagram of plates surrounding the anal area, enlarged.

Fig. 9. Lingulops cliftonensis, Foerste. Pedicel valve, enlarged. Richmond group, at Clifton, Tennessee.

Fig. 10. Acervularia (?) paveyi. Radiating septa apparently interrupted half way from center by a cylindrical wall, the actual presence of which has not been fully verified. From the upper part of the West Union formation at Hillsboro, Ohio.

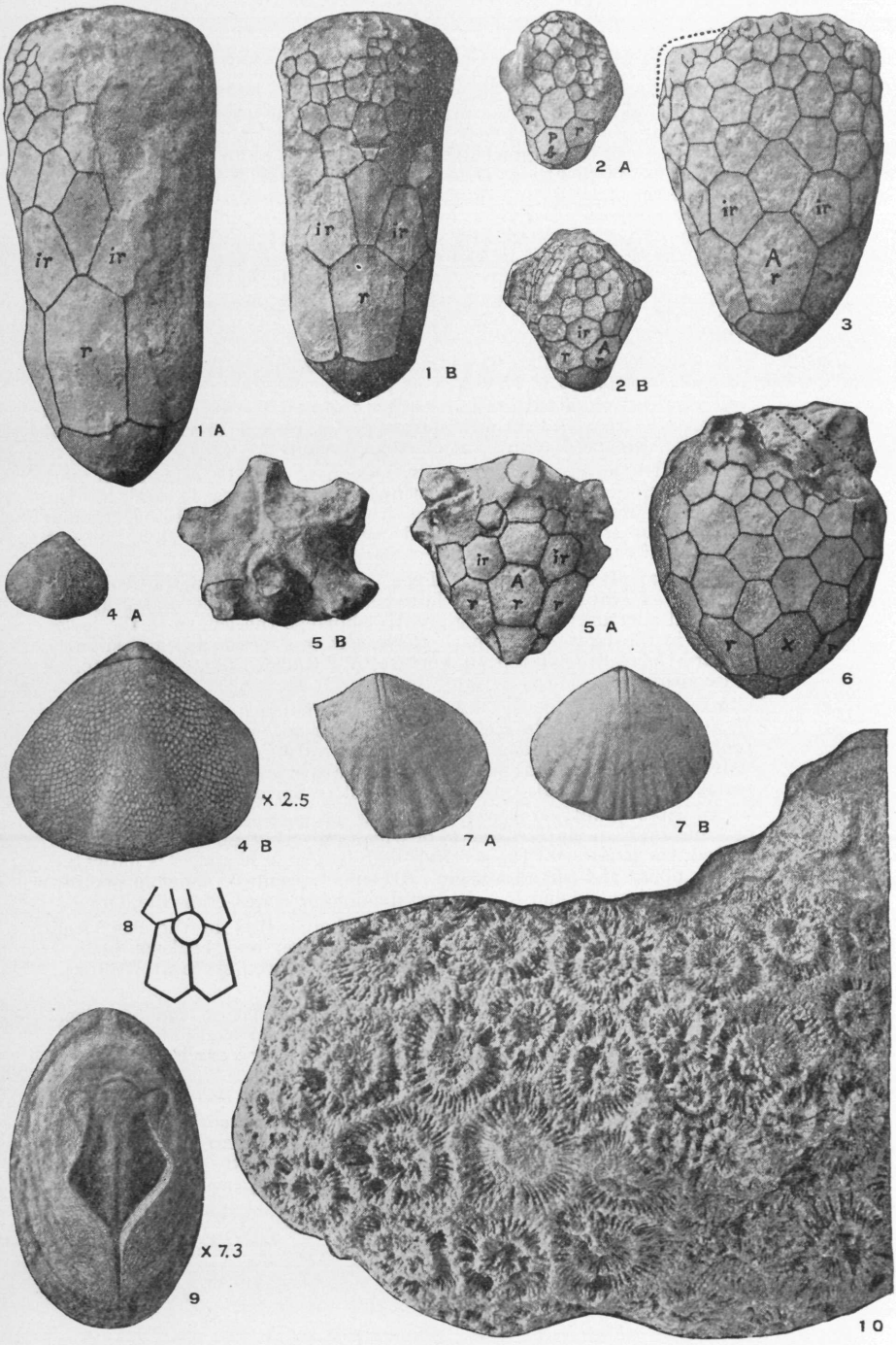


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PLATE XI.

Fig. 1. Trochurus phlyctainodes. A, dorsal view of cranidium with subtriangular occipital segment, exposing occipital lobes near the lateral extremities of this segment; B, same, tilted so as to show the anterior border; C, anterior view; D, lateral view; b, anterior border; s, probably spinose tip of occipital segment; e, angle of facial suture at palpebral lobe; x, broken margin of fixed cheek, outline unknown. In figure A, the fixed cheek extends beyond the margin of the third lateral lobes; in B, the third lateral lobes form the bulbous outlines at the rear, and that part of the facial suture extending from the anterior border to the palpebral lobe is not preserved; in D, the occipital lobe is indicated. Cedarville dolomite, at eastern Mills quarry, southwest of Springfield, Ohio.

Fig. 2. Hallicystis imago, Hall. Type, numbered 2025 in the American Museum of Natural History in New York City. Left margin imperfect, broken off. Indication of path of gut leading from anal orifice downward and toward the right. Pectinirhomb on plates 14 and 15 visible on right margin. Racine dolomite, at Racine, Wisconsin.

Fig. 3. Callocystites jewetti-elongata. Impression of cast of exterior of part of a specimen showing the pectinirhomb on plates 14 and 15, the depressed linear area left by the dropping off of one of the ambulacralia, and the distinctly pitted surface. Cedarville dolomite, at eastern Mills quarry, southwest of Springfield, Ohio.

Fig. 4. Holocystites alternatus, Hall. Type, numbered 2020, in the American Museum of Natural History. Tilted so as to show the plates around the anal aperture; this tilting greatly shortens the length of the lower plates in the figure. The path of the gut was downward and slightly toward the right from the Anal orifice, A. Racine dolomite, at Racine, Wisconsin.

Fig. 5. Dalmanella springfieldensis. A series of internal casts; A, pedicel valve; B, anterior view; C, lateral view of another specimen, all showing the prominent dental lamellae. D, brachial valve with beak of pedicel valve at top; E, lateral view of the same specimen. Cedarville limestone, at eastern Mills quarry, southeast of Springfield, Ohio.

Fig. 6. Callocystites jewetti-elongata. A, view of cast of interior, showing pectinirhomb on plates 1 and 5, of which only the half on 5 is well preserved; the location of the pectinirhomb on plates 12 and 18 is indicated at the upper right-hand margin. B, same specimen, showing pectinirhomb on plates 14 and 15. Cedarville dolomite, at Cedarville, Ohio.

Fig. 7. Dictyonella reticulata, Hall. Type, numbered 1944 in the American Museum of Natural History. Brachial valve, and beak of pedicel valve, enlarged 2.6 diameters. From the Waldron shale at Waldron, Indiana.

Fig. 8. Dictyonella corallifera, Hall. Type, numbered 1790, in the American Museum of Natural History. From the Rochester shale at Lockport, New York. Original or figure 5c on plate 58 of New York Paleontology, vol. 2, enlarged 2.6 diameters.

Fig. 9. Grabauphyllum johnstoni. Interior structure, near upper surface of corallum, seen from beneath. Central tabulae, smooth beneath; intermediate zone of septa connected by disseppiments well shown at A; exterior zone of cysts and walls separating corallites seen above and toward the right of A. Niagaran dolomite, quarry near McCook, five miles southwest of Chicago, Illinois.

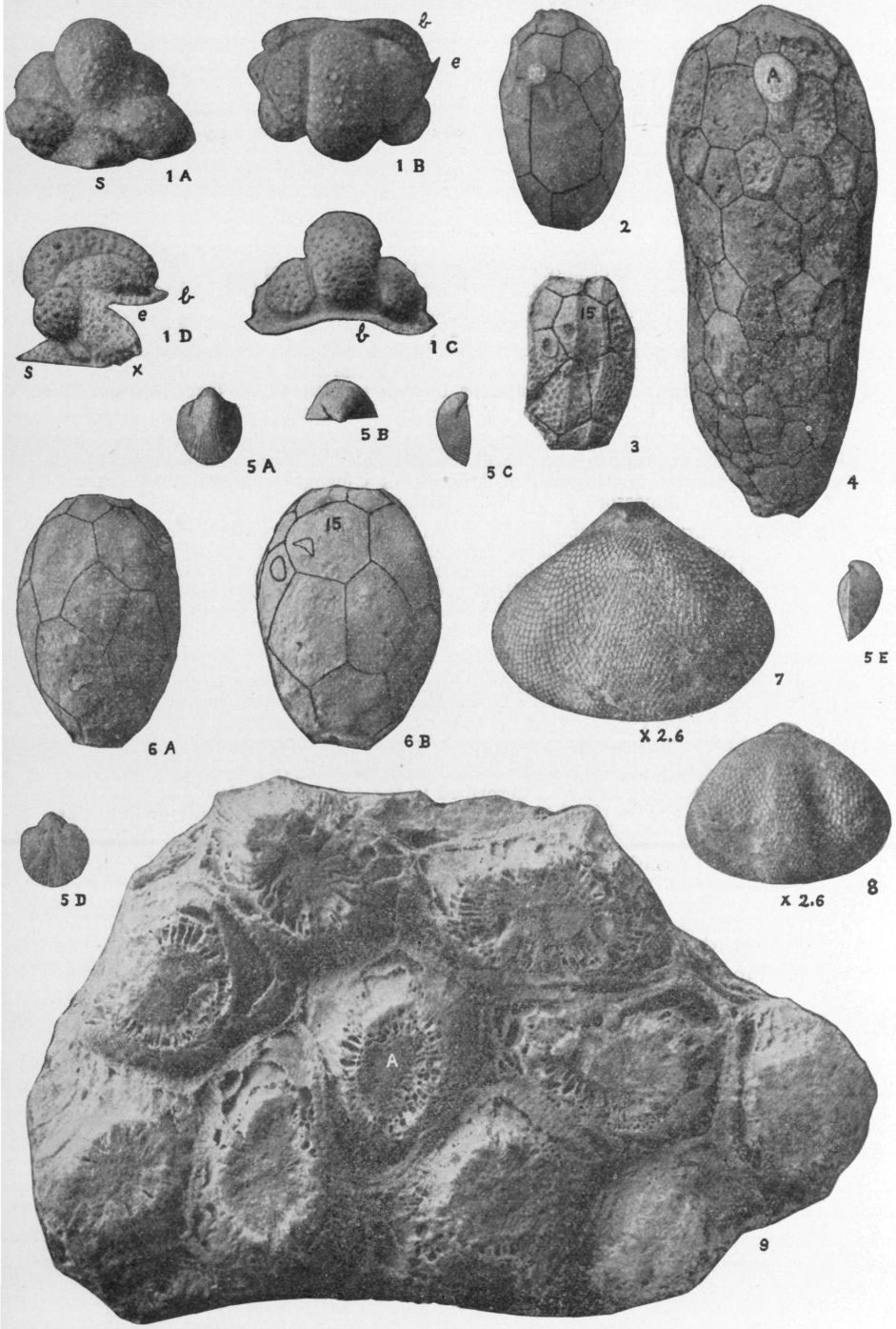


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PLATE XII.

Fig. 1. Trochurus phlyctainodes, Green. Cast of type prepared by Green and numbered 54 in his series of casts of Trilobites. Original found in the Cedarville limestone at Springfield, Ohio. In this, and in the following series of figures of species of Trochurus A represents the dorsal view of the cephalon; B, anterior view of the dorsal part, secured by tilting the cephalon until the anterior border is horizontal; C, anterior view of cephalon, with the anterior border transverse to last position; D, lateral view, with dorsal side on left in figures 1, 3 and 4, but forming upper outline in figure 2.

Fig. 2. Trochurus hanoverensis, Miller and Gurley. Type, numbered 6141 and preserved in the Walker Museum of Chicago University. From the Laurel limestone at Madison, Indiana.

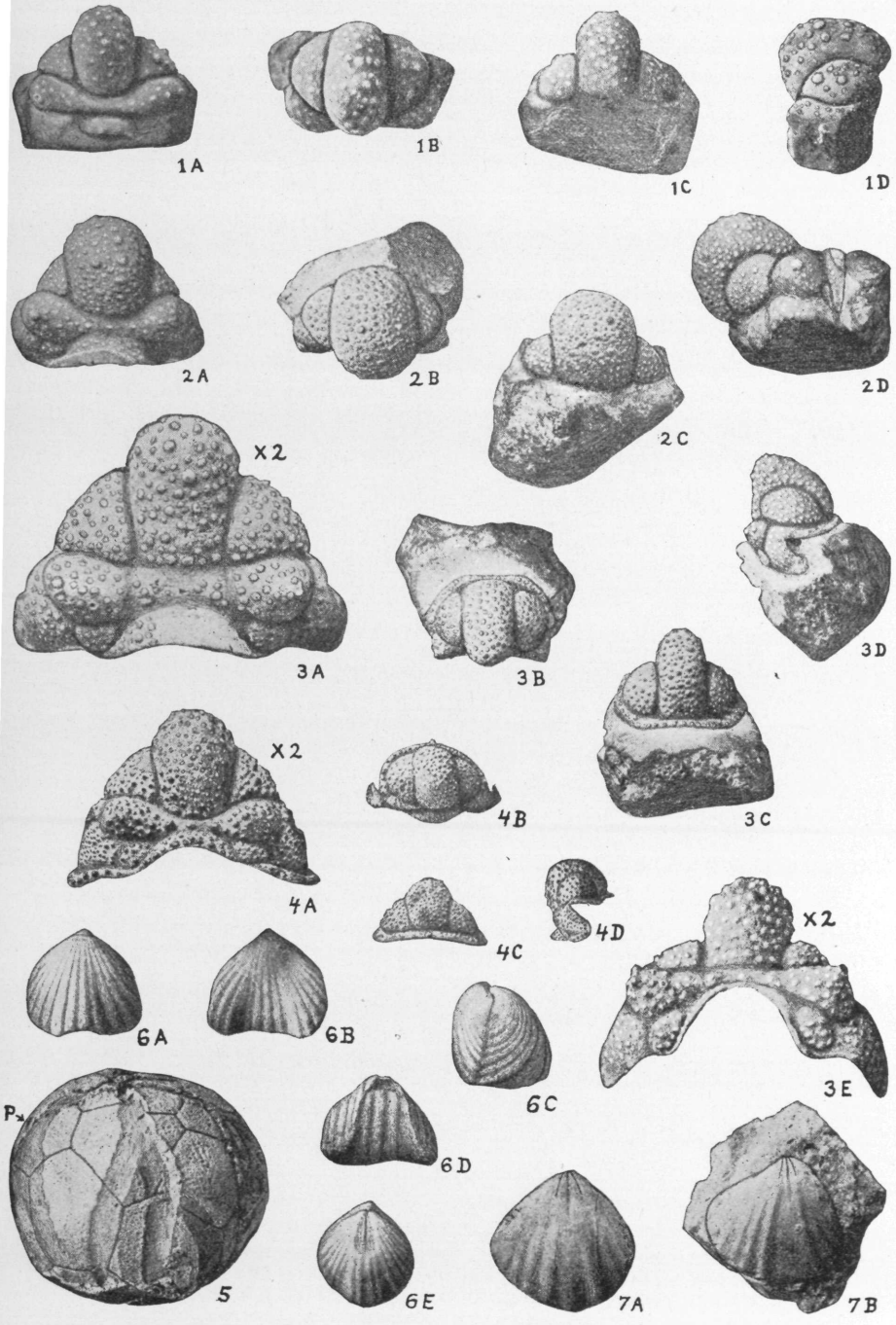
Fig. 3. Trochurus byrnesanus, Miller and Gurley. Type, numbered 6839 and preserved in the Walker Museum at Chicago University. From the Laurel limestone at Madison, Indiana. A, E, enlarged two diameters. In E, the cephalon is tilted toward the front so as to show the upper outline of the third lateral lobes, a direct view of the occipital lobes, and the posterior part of the fixed cheeks, their raised granulated posterior border, however, being absent.

Fig. 4. Trochurus halli. Original of figures 2 a, b, c, on plate 70 of volume 2 of the Paleontology of New York, numbered 1826 in the American Museum of Natural History in New York City. A, enlarged two diameters. From the Rochester shale, near Albion, New York.

Fig. 5. Callocystites sphaeroidalis. From an impression of a cast of the exterior, crossed by a crack as described in the text; p, location of the discrete half of the pectinirhomb on plate 15. From the Cedarville dolomite at Springfield, Ohio.

Fig. 6. Camarotoechia roadsi. A, brachial valve; B, pedicel valve; C, lateral view; D, anterior view showing depth of sinus; E, cast of interior of brachial valve of a second specimen, showing muscular area and median septum. From the lower part of the West Union formation on the southeastern margin of Hillsboro, Ohio.

Fig. 7. Prosserella (?) sp. Two casts of the interiors of pedicel valves, showing vertical lamella supporting the teeth, and also a median septal ridge. From the Cedarville dolomite at Cedarville, Ohio.

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